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MACHINE MOLDING.

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(Member of the Society.)

Of all the mechanical arts, that of molding has been the most difficult to formulate and to reduce to a system. Since the origin of metal-founding the molder has been pleased to shroud his methods in certain mysteries, which, to him at least, seem essential to perfect castings. It may be said of this trade, more than any other, that the traditions of generations cling to it. Like the good housewife of the olden time whose bread was often sweet and delicious and occasionally intolerable, the man of rammer and trowel will alternately score success and failure under apparently the same conditions. He can always tell why his casting is good, but can rarely give a reason when it is bad. There is much which can be accounted for in this; perhaps more that cannot be. In all other industrial branches the senses of touch and sight are always at the command of judgment. In the machine shop, contact between the workman and his work is always possible; an error may be detected as soon as made, and corrected at once; there are no final chances upon which the success of the machinist's job depends. With the molder, it is different. The conditions which insure bad work, and cannot be anticipated, are numerous. There may have been a bar in the "cope" under enough tension to induce a "drop" when the additional "strain" of clamping was put on; the core, with which he had nothing to do beyond setting, may have been made with no reference to free "venting," and a "blow" follows pouring. His troubles do not end here; the melter may have been in a careless mood to the extent of dull iron, and a casting with "cold-shuts" is his reward; if his foreman make a wrong estimate on the amount of iron necessary to "pour" his mold, and give him too little, another loss will be charged to his account. There is much, beyond the control of the molder, in the art of metal-founding, which tends to make bad castings. His strongest influence upon the quality of his work lies in skill which cannot be verified by caliper, gauge, or rule.

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The molder's art is in making the mold of the proper density. Drawing a pattern from the sand after it has been rammed, and mending a broken mold, are mechanical operations easily taught. It is not so with ramming. If a touch of genius enter into molding, it is shown in making the mold of such density that it will stand pouring without "straining" and be soft enough to prevent "blowing" and "scabbing," with a certainty that the sand will remain in place until the iron has solidified. This is the molder's skill which cannot be formulated and passed down to succeeding generations, in books. Ramming a mold from the top to produce a required density on the under side may seem a simple operation to the layman, but a trial will convince him of one difficulty in molding. After he has learned to ram a flask with a given depth of sand, should he try one half as deep, he will discover his previous experience has not made him an all-around molder. This point is well illustrated in many large foundries doing duplicate work, where unskilled labor has been taught to mold a single pattern. In such cases, it is an invariable rule that it is not safe to change a man's work without putting him through a system of training on the new pattern. The writer has been told by foremen in such foundries that men who did excellent work on patterns which they had been taught to mold, were worthless on any other. In these cases the difficulty is in ramming and pouring, principally in ramming.

There can be no gauge to determine the force of the rammer's blow. It is a question of experience supplemented by good judgment. Some men have a capacity for acquiring this skill beyond others, and they are slow to impart it. On this account we see a greater relative difference in the skill of molders than in any other trade, and it is for this reason that there are so few molders coming to take the place of the old school which is disappearing.

As a rule, the foundry has less support from the office than any other department. Its conveniences and comfort are the last to be considered. Nearly all members present can call to mind plenty of establishments where the machine shop is a model of excellence in the way of modern tools, is warmed to a comfortable temperature, and shows signs generally of a kind consideration for the workmen; while the foundry is the same old kind with which we are familiar, filled with broken flasks, with no system of heating, and ventilated only through broken windows. There are no follow-boards or match-plates (the initial steps to machine molding) to cheapen processes. Even the core-boxes are misfits, and the work of filing cores to fit prints is equal to the cost of making the mold. There is a general air around the place which seems to indicate that the machine shop comes first, and the foundry last, in the affection of the manager. The foundry deserves a better consideration. It is here that the first step in machine construction is taken. It is here the first money is made; in fact, in a majority of cases, the foundry is the telling factor in the financial success of the manufacturer of iron products.

There is no doubt but the difficulty in formulating the molder's practice has had much to do in withholding improvements from this department. Skepticism prevails, which it is hard to overcome except by actual proof. In other departments a machine or fixture which has proven valuable in one shop may be sold to another on the strength of its record. In the foundry, success must be shown in the individual case before consideration is given. This doubt is gradually giving way under fierce competition. One year of low-priced castings will do more to set an iron founder thinking, than a dozen years' experience with prices of his own making.

The development of machine molding has been gradual, covering a long period. The follow-board which covers, or shuts off, from the sand that portion of the pattern above the joint line, was probably the first change from the original method of molding in boxes. The match-plate, which is a plate fitted with pins and pinholes for the flask, with a portion of the pattern fitted thereon like a medallion, came next. This was a greater improvement, for it compelled the flasks to be interchangeable. Silhouette, or stripping-plates, followed with decided advantage. The stripping-plate, often called drop-plate, is a plate cut out to receive the outline of the pattern at the joint line; enough is added to the pattern to project through the plate to the pattern base. Like the match-plate it is fitted with pins and holes to receive the flask; it is also a molding table, or board on which the flasks are rammed. Originally, this plate was turned with the flask, and the pattern drawn through the plate by hand. Modifications of the stripping-plate are numerous, nearly all embodying a frame or table, with lever attachment for drawing the pattern without turning the flask. A good illustration of this type is the machine for molding pulleys.

The evolution of the power machine from the hand machine was natural. The deep-rooted prejudice on the part of the workman has had its effect on the development of so great an innovation in foundry methods, and its progress has been slow. There are, however, a number of excellent power machines on the market; operated, respectively, by belts and cams, hydraulic, pneumatic, and steam pressure. It is not the purpose of this paper to discuss the merits of these various machines, but to touch upon some of the difficulties in the way of introducing machine molding in the foundry and the many advantages resulting therefrom, and incidentally a form of steam-operated machine with which the writer is identified.

All ramming machines may be said to have platens, of which there are two types: rigid and flexible. The rigid platen is simply a block of sufficient size to cover the surface of sand in the flask; the flexible platen is one which yields to irregular depths of sand, and exerts a like pressure on all parts of the mold. Of the flexible platen there are two: (1) the water bag, which is a rectangular box with a rubber diaphragm for the bottom, filled with water; (2) a group of rammers, equal in size to the flask to be rammed, hung on equalizing levers so that each rammer is independent of its fellows. At first thought, the flexible platen would seem to be perfect. If sand, under pressure, flowed like water, and its required density over the pattern was the same as needed on the joints of the mold, nothing could be better. But these conditions do not exist. The friction of sand upon itself and upon the walls of the flask, makes it comparatively unresponsive when rammed by equal pressures; if we add the fact that the mold, to pour well, should be softer over the iron than at the joints, we see that uniform pressure on a mold falls short of the requirements; it is better, however, than the rigid platen and requires much less hand work in the way of ramming and tucking. As an evidence of the difficulty in making equal pressures suit all conditions, a case can be cited where we had a pattern projecting vertically about 6 inches in the sand; at this point the side of the flask, which was 8 inches deep, came within 2 inches of the pattern. The average pressure, per square inch, over the mold was 40 lbs.; the pressure put over the narrow belt of sand between the flask and pattern was 70 lbs. per square inch, leaving only 28 lbs. per square inch over the higher portion of pattern; yet, notwithstanding the deep sand had $2\frac{1}{2}$ times the pressure exerted over the lesser depths of the mold, it was necessary to precede the work of the machine rammers at this point by hand tucking. This was an unusual case. It is true, in all cases, that more pressure is needed along the walls of the flask to overcome the friction of the sand; hence we have found it necessary to arrange our rammers to produce this result, giving the marginal rammers about 50% more pressure. This does not always give perfect ramming, and occasionally it is necessary to do some hand work, but as a rule this arrangement of rammers gives good results without hand manipulation.

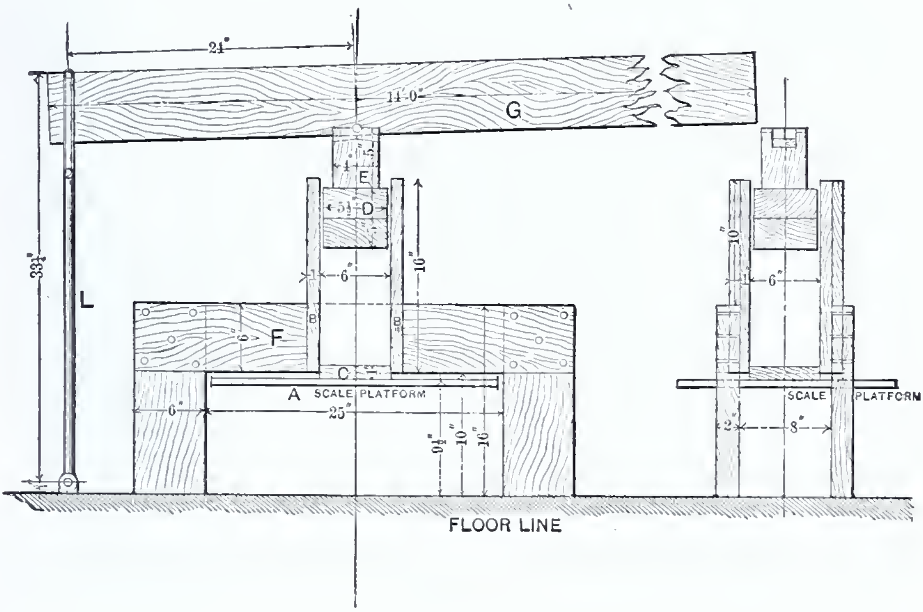

Fig. 142.

In the spring of 1890, Mr. A. B. Moore, who was then a Stevens Institute senior, selected the rammer machine as the subject for his thesis. We discussed the lack of data bearing upon the friction of sand, and decided jointly to make experiments.

An ordinary platform-scale was used for weighing. A series of boxes, 4 × 4 inches, 5 × 5 inches, and 6 × 6 inches was decided on; these boxes were supported by frames spanning the scale and resting on the ground (Fig. 142); each box was fitted with a loose bottom which rested on the scale platform; the plunger used for ramming fitted its box loosely enough to avoid serious friction, and was connected to the weighted lever by a turned joint; the weight of the lever on the sand was found by weighing it in position. In all cases the scale was weighted to a pressure equal to 10 lbs. per square inch on the under face of the box. (This is about the density of the average mold surface.) We began with the 4 inches square box as follows: $2\frac{1}{2}$ inches of loose sand was put in and compressed until the scale-beam tipped; the intersection of the dotted line with 4 × 4-inch curve (Fig. 143) shows that the $2\frac{1}{2}$ inches of loose sand was compressed to $1\frac{11}{16}$ inches to give a density equal to 10 lbs. pressure on the under side, and it required a pressure of $12\frac{1}{2}$ lbs. on top of the sand to produce this result. With 5 inches of loose sand, $17\frac{1}{2}$ lbs. pressure was required on top to give 10 lbs. below; an addition of $2\frac{1}{2}$ inches in the depth of sand brought the ramming pressure up to 34 lbs., and the last $2\frac{1}{2}$ inches (making 10 inches) required a pressure of 42 lbs. to give 10 lbs. on the scales. With the 6-inch box only $11\frac{1}{2}$ lbs.

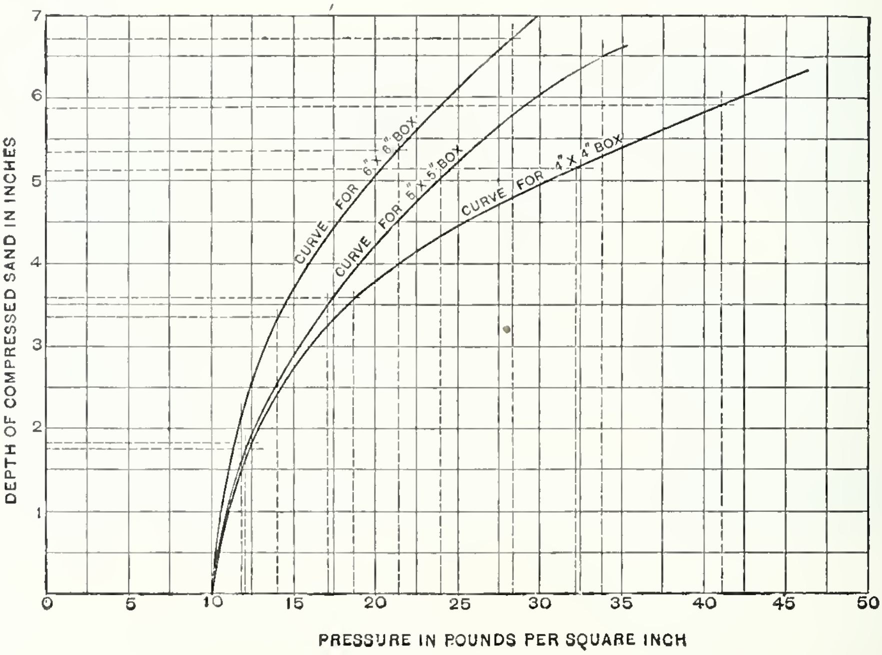

Fig. 143.

were needed to give 10 below, with $2\frac{1}{2}$ inches of sand; with 10 inches, 26 lbs. raised the scale-beam, or 16 lbs. less than was required, under precisely the same conditions, with the 4-inch box. The walls of the boxes were of undressed plank, to represent the average condition of wood flasks. The friction on iron sides would have been less.

There are several methods of anticipating unequal depths of sand in machine molding. With the rammer system greater pressure may be given over portions of the mold which would otherwise be too soft. When flasks are of such size that bars are necessary the rammers are arranged to straddle them, thus doing away with all tendency of the bars to spring; this method also avoids the necessity of tucking under the bars. When the flat platen is used for ramming, sand may be scooped away from the higher portions of the pattern until the best result is obtained; where the flasks are not too large, sand will flow sufficiently to give excellent results when this plan is followed. With all our automatic machines we use the rigid platen for ramming; we make this of hard wood, which we cut out boldly over the pattern, and without much reference to the shape of the pattern; the amount cut from the ramming head is about 50% more than the displacement of pattern for ordinary cases. By this method no skill or judgment is required in putting sand in the flask, and the density of mold over the iron may be made to suit any condition. On small work, up to flasks 24 inches square, we get the best results from this system. We have a method of using flask-bars for ramming, which seems to suit certain conditions better than other methods; the bars are detached from the flask, and are made enough smaller so that they may be forced down without coming in contact with its walls; the flask and sand-box are filled with sand, and the bars forced down by a flat platen; the bars are deeper where the greatest ramming is required, and are made wedge-shaped at the bottom so that one bar will spread the sand until it meets the spreading influence of its neighbor. With this plan it is sometimes necessary to use a bottom board on the drag, to hold the bars when the drag is turned; the bars in the cope will hold in position against the pressure due to pouring.

An idea of the rammer connections may be obtained from the engraving showing details (Fig. 144); the rammers are hung to the ends of the cross-bars, which are grouped together by ball-

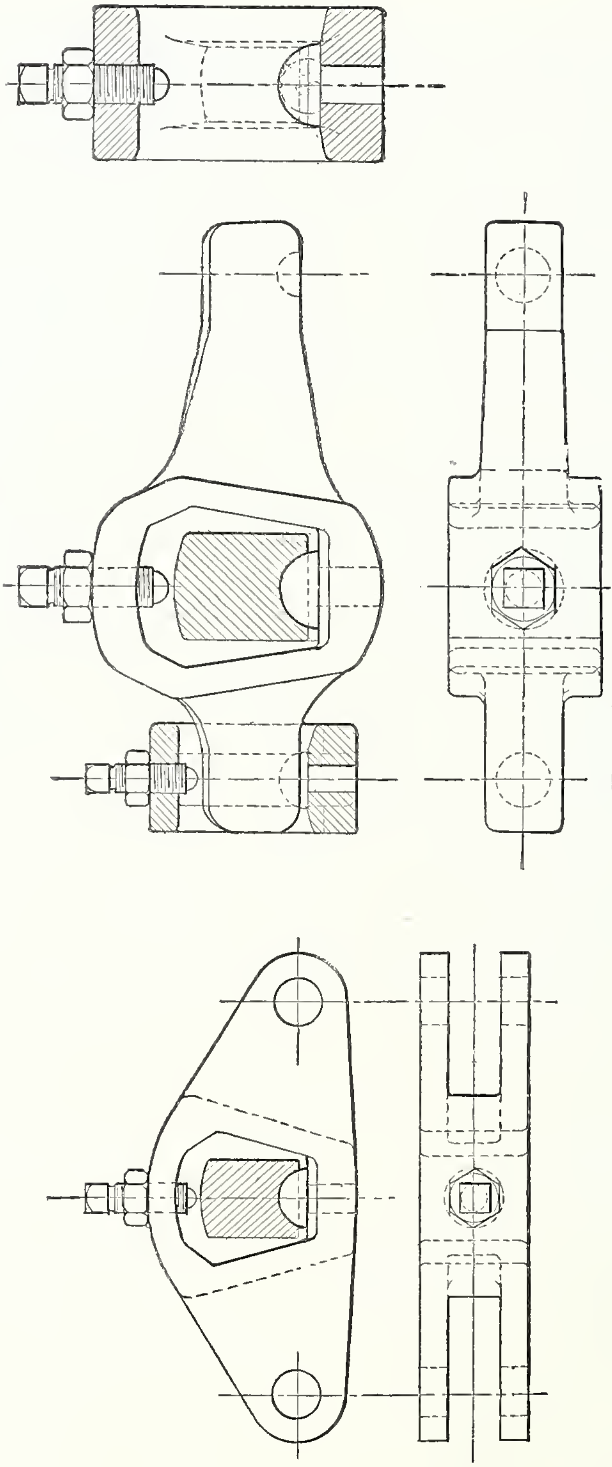

FIG. 144.

joints and operated centrally by a steam piston. The flasks are placed on trucks, which are topped with stripping plates and contain mechanism for drawing the pattern; the trucks are run under the machine for ramming, and withdrawn to take off the mold and replace the flask.

A description of such an automatic machine (taken mainly from the columns of a technical journal *) may be conveniently introduced here to illustrate the operation of these principles :

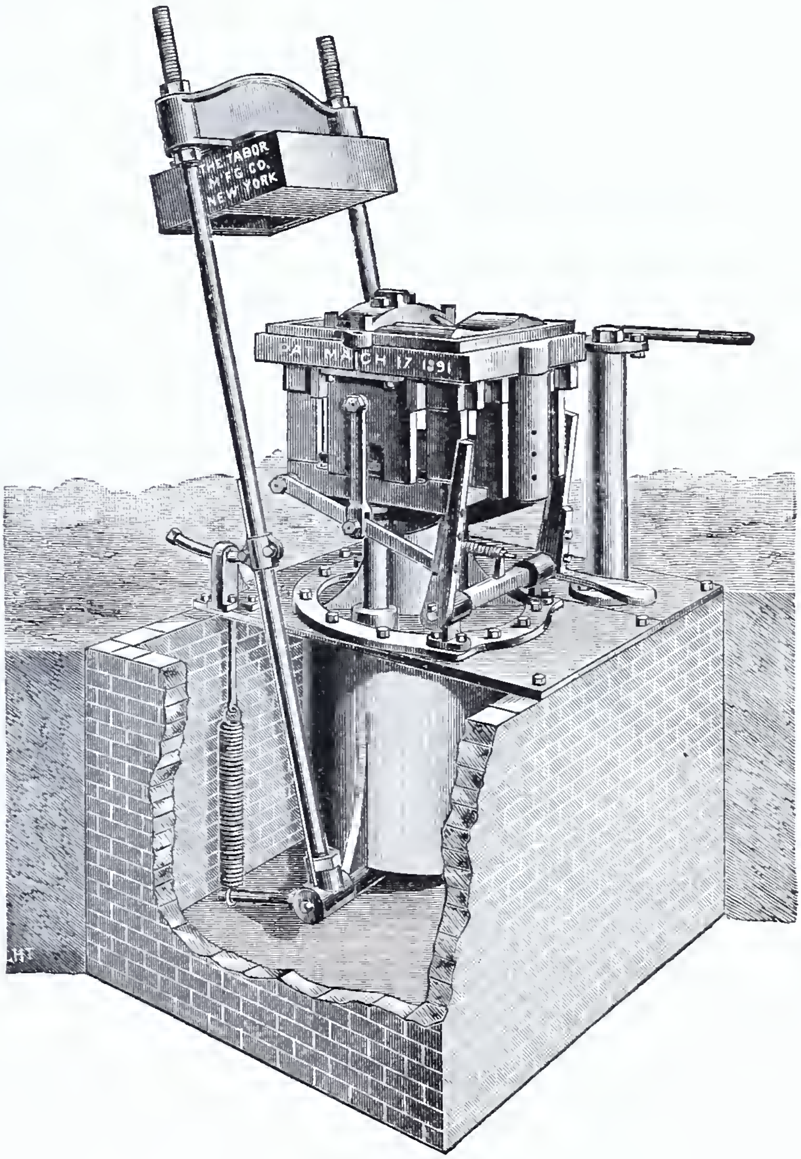

Fig. 145.

Fig. 145 shows the floor broken to give a view of the machine below the floor line ; and Figs. 146 and 147 show sections made

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* *American Machinist,* of New York, October 22, 1891.

from working drawings. The piston takes steam on the under side only, its weight being sufficient to return it promptly after the mold is rammed.

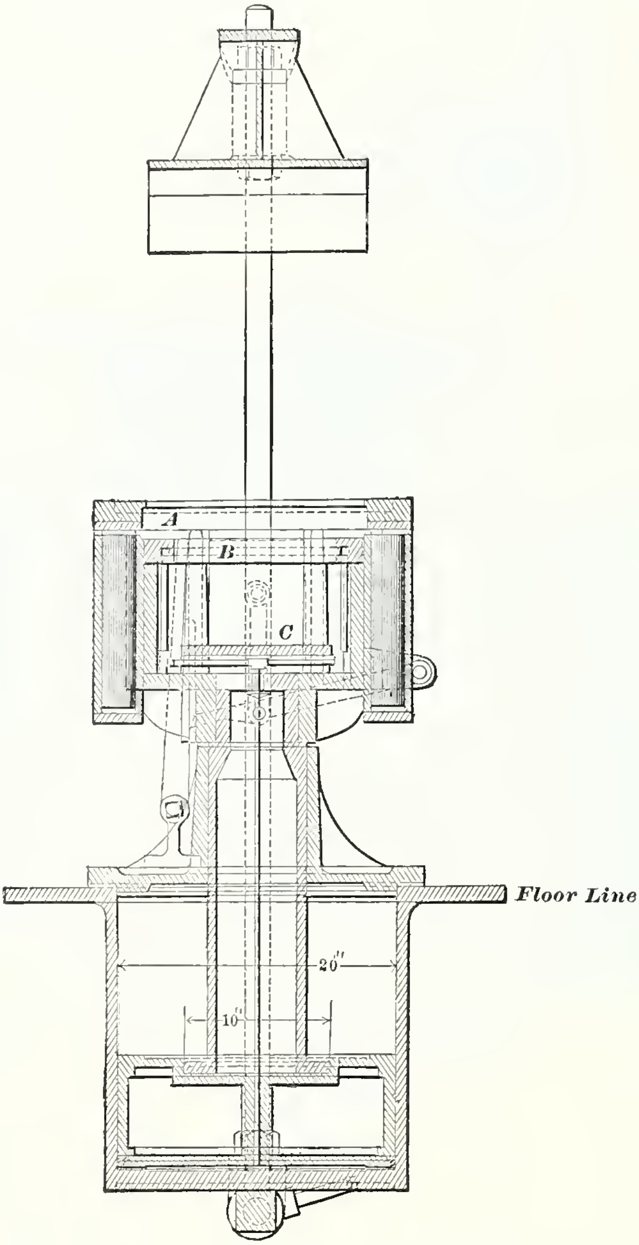

Fig. 146.

To the piston rod is attached the principal part of the mechanism, consisting of a table with lugs projecting upward, and supporting the pattern frame *B*, upon which rest the patterns; the stripping-plate frame *A* directly over the pattern frame, and resting on it, to which the stripping-plate is attached; the stool-plate *C* suspended to the stripping-plate frame, and

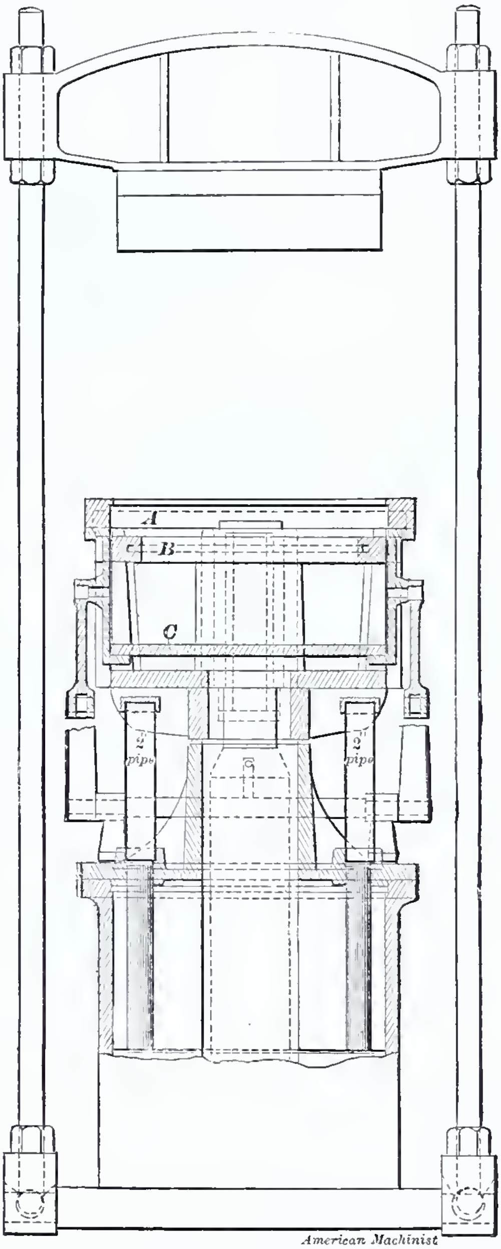

Fig. 147.

moving with it; side levers and tumbling shaft for tripping after the pattern is drawn. The pattern frame has an annular passage which is connected to the cylinder by the small pipe shown, the object of this being to admit some steam to the pattern plate at each movement of the piston, this steam serving to keep the patterns moderately warm, preventing "sweating" or accumulation of moisture from the atmosphere, and making them draw from the sand more freely and smoothly. The stripping-plate frame is guided by two bored sockets, one at the front, and the other at the back of the machine, there being air-holes below the pistons, by which any desired amount of cushion can be obtained for the drop of the stripping-plate frame. The stool-plate is really part of the stripping-plate frame placed below the pattern frame, and its object is to support stools or internal parts of the stripping-plate used in holding green sand cores, or heavy bodies of hanging sand, while the pattern is being drawn. The side levers are pivoted at one end to the table, and are connected at the middle, by links, to the stripping-plate frame, the outer end being free. The tumbling or tripping shaft is in front of the machine, near the floor, and has arms projecting upward along the line of travel followed by the free ends of the side levers ; on these arms are stops which engage with the free ends of the levers on the downward motion, to draw the pattern.

The ramming head (Fig. 148) is carried by the wrought rods seen at either side of the machine, these being attached to a horizontal shaft at the bottom of the cylinder, which allows them to be swung forward and back as shown, a spiral spring being used to counterbalance the weight. The ramming head is usually of wood, roughly cut out over the pattern, to avoid too hard ramming on the high places. This block may, of course, be readily changed to suit any flask within the capacity of the machine. The stops on the stripping-plate can be also changed to suit any pattern within the range of the machine. The steam pipe enters the cylinder at the bottom, and from the throttle valve to the cylinder serves also as an exhaust pipe, the throttle valve being a two-way cock by which steam is either admitted or exhausted from the cylinder.

The operation of the machine is very simple. The half flask is put on the stripping-plate, with the sand-box to hold the sand which is to be compressed, and both are filled with sand. The ramming head is then swung forward over the flask against stops which define its position, and the throttle valve opened. The upward motion of the piston and attached parts carries the flask and sand up to the ramming head, where it is rammed instantly, and upon the throttle-valve lever being moved again, steam is cut off, and at the same time exhausted, allowing the flask to descend; the stops then engaging the free ends of side levers, and arresting the downward motion of the stripping-plate at a point about midway; the pattern, continuing to descend, is drawn from the mold, and when the piston has returned to its lowest position the sand is struck off the flask, which is then taken from the machine. As the man removes it he presses the tripping treadle with his foot to release the stripping-plate frame, which then falls to its proper position with respect to the pattern, and the machine is then ready for another mold.

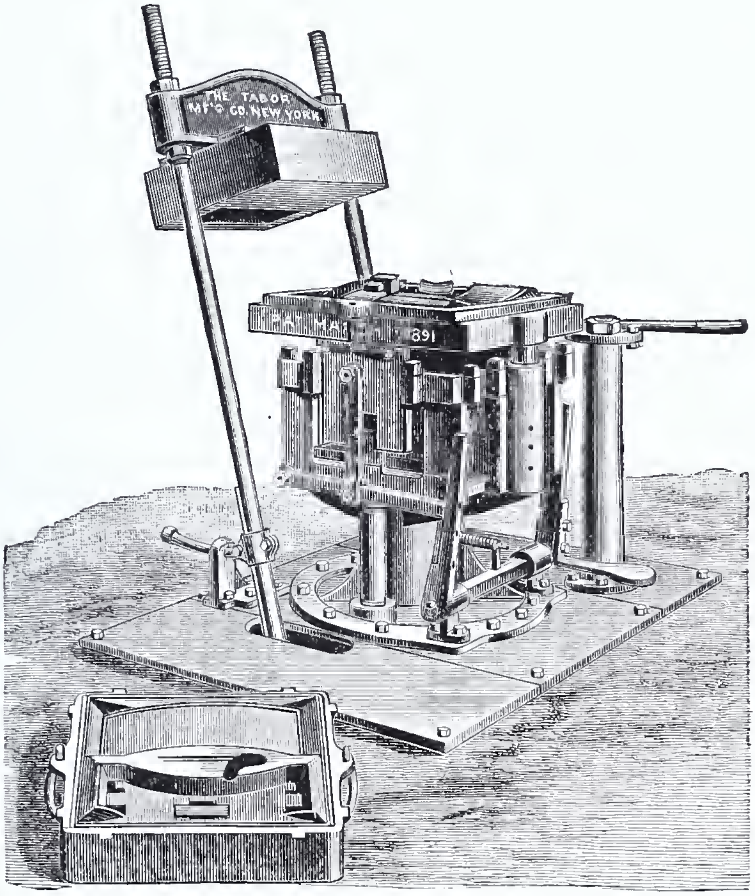
THE TABOR MF'G CO. NEW YORK
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FIG. 148.

Water or compressed air may be used instead of steam, if it is desirable, though it is believed that steam is preferable in most cases; because it is usually easily obtained without the use of other special auxiliary machinery of any kind; it is cheaper, and the steam appliances coming under the charge of the fireman or engineer, the foundry is relieved of the care of them.

Good molding machines in a foundry where there is a fair amount of duplicate work may be made as profitable as the turret lathe has been in the machine shop. It has been said of the turret lathe that its limit is set by the ingenuity of the tool maker. If pattern maker be substituted for tool maker, and a fair amount of "nerve" in foreman be added, the same may be said of the molding machine. Like the turret lathe, its best results are obtained when operated by unskilled labor, or men trained only in the use of the machine. When the foreman has a reasonable amount of patience at the start, coupled with a disposition to make good castings cheaply, there is no doubt of his success in machine molding. If these qualities are lacking, it is better to defer the introduction of machines until the foreman has been brought to see their advantages, or has been supplanted by a more progressive man. We have a case where the manager of a large iron foundry came to see a machine making castings similar to his own. He was especially interested when he saw a duplicate of one of his patterns on the machine, and tons of machine-made castings in the yard for his inspection. There was no doubt, in his mind, of the value of molding machines in his business, and he wanted to introduce them. The question was left to his foreman, who decided against the purchase after seeing a machine in operation, and admitting the work was much better and cheaper than he could produce by hand. Here was a case where prejudice, or fear of a change in methods, overruled judgment. In another case, parties who are engaged in a competitive business, noted for low-priced castings, sent their foreman on a similar mission; on his return he insisted that one be furnished him, and their order for a machine followed. We have one more instance on record of a foreman demanding machines. Such cases, however, are not the rule.

If a builder of machine tools sell a machine under a guarantee that it will produce given results, and the purchaser fail to get them, the maker can send a man to make good his claim if the machine is as advertised. This cannot be said of molding machines. There are so many conditions and operations in the process of making castings, independent of the mold, which have their influence, that the molding machine vender cannot verify his work in any foundry but his own, unless he have the hearty co-öperation of the foreman. The most perfect mold may be ruined in pouring; a defective core may produce a blow for which an innocent machine would get credit; a vicious kick given to a flask might cause a drop of sand, and a handful of dirt dropped in the pouring hole will spoil what otherwise would have been a perfect casting. These are conditions beyond the reach of the molding-machine maker; and, if they exist, and he cannot have the support of the foreman, his case in that particular foundry is hopeless. But when he can count on the same encouragement that is given to the machine-tool maker by the machine shop, his showing will be quite as good.

Consideration has not always influenced the introduction of molding machines. Unlike all other merchandise, they should not be sold by the purely commercial man. The seller must have a fair knowledge of molding and general foundry work if he would avoid serious trouble; he must understand first, and all the time, that it is better to lose a sale than to place a machine where conditions are against its success. In too many cases cumbersome power machines that are slow in operation and expensive to handle, have been recommended to do work that should have gone on a different machine or been left to the molder's rammer. There are plenty of foundries in the country making a specialty of light bench-work that could not afford to use our rammer machines; but in these foundries our automatics would make a wonderful reduction in the cost of molding.

It is a mistaken notion that stripping-plates and metal patterns must be used on power machines. In 1887 we sold a twenty-four-inch rammer machine to parties operating a steel foundry. Each year since they have ordered more machines, and now they have eight, varying in size from 18 × 18 to 44 × 44 inches. Much of the time these machines are run night and day. Not more than two, and probably only one, have ever had a stripping-plate. There is nothing special in their business to warrant expensive patterns. Their work is general, and usually made from patterns sent them. If an order come for twenty-five castings from one pattern, they at once scheme to get it on a machine, and generally with success. They keep on hand, boards fitted with pins and pin-holes to match their flasks, on which they dowel the pattern, each half going on a board.

These boards are placed on the machine truck, with the flask over them, filled with sand and rammed under the machine. The pattern, of course, is drawn by hand. Each machine is operated entirely by laborers; one, brighter than the others, has charge of the machine and draws the patterns. When the 44 × 44-inch machine was in the course of construction, the superintendent of this foundry happened to be in the shop. He saw this machine on the floor and said that he was just finishing an order for fifty castings, weighing 1,500 lbs. each, and that he would have made them all on this machine if it had been in his foundry. I have never seen an instance where machine molding is so generally used as in this case.

The all-absorbing question: What is the economy in machine molding?—is very difficult to answer. The product of machines will vary in different foundries, as much as the product of the molder. What may be called a fair day's work is an unsettled question. From the standpoint of manufacturer and workman it is too small in some localities, and too great in others. A machine that will mold 175 flasks, 16 × 16 × 10 inches deep, with two men to operate it, in one foundry, would, under precisely the same conditions, mold 250 in another. One manager may surround his machine with little conveniences for handling work, and thus increase his product, while another would compel the machine men to work under disadvantages. The treasurer and practical shop man of a foundry were observing the operation of an automatic machine, with watch in hand; a complete half mold in 16-inch nowel, or, as they would say out West, drag, 5 inches deep, had just been made and turned on the floor for inspection in ten seconds after the sand was put in the flask, when the treasurer asked the question: "How many molds can be made in a day?" Before the writer could reply the shop man said: "That is not the question; the question is, How many molds can we take care of?" A better answer could not have been given. The first machine of our automatic type has been in use about a year. The conditions are not favorable; all the sand is handled by shovels, and the flasks and molds are carried to and from the machine by hand. The flasks used in this case are 14 × 17 × 10 inches deep, and weigh 70 lbs. The sand in flask, when rammed, weighs 156 lbs. Two men on this machine make 200 molds per day, and average during the working hours from 27 to 34 molds per hour. These men have made and carried away 158 nowels in one hour and thirty-five minutes, and have made 200 complete moulds, ready for clamping, in less than five hours. We must keep in mind that these two men must shovel into flasks over 31,000 lbs. of sand, and carry off the same amount, in making 200 molds; they must also handle twice 14,000 lbs. of iron in flasks. 200 molds, under these conditions, is too much for five hours' work. But this number is not too much for a day's work for two men. A greater product might be obtained from an additional man, or from a conveyor for elevating sand to a hopper over the machine. A system of handling the molds after they are made would also add to the machine's capacity.

DISCUSSION.

Mr. M. P. Higgins.—The importance of this subject is so great that I would be very glad to have some expression of ideas from the members of this Society. I think we will all admit that the importance of the foundry as a step in machine building is growing more and more apparent from year to year, and I doubt very much if it is keeping pace with other branches of machine production. I think the possibilities of the foundry have not received so much attention as other steps in building machinery; I doubt if it has had its due share of scientific investigation. There are many matters connected with the subject of this paper about which I would like to know.

For instance, we want to know, scientifically and accurately, what constitutes a good sand for foundry uses. We know that for a distance of 500 or 1,000 miles around Albany there is no sand quite equal to that which is obtained there. If it has not already been done, it is desirable that scientific men analyze the sand, chemically and physically, and let us know exactly what it is. If we can determine that, it seems to me that it will affect this question of machine molding, because it has been shown that extreme accuracy of ramming and condensation of the mold is necessary; but, of course, if we can use a kind of sand which is strong enough, and yet is porous enough, that extreme accuracy may not be required.

In regard to the possibilities in the direction of unusual and exact results in the foundry, I would like to mention what I have done and have seen. I have seen some remarkable pieces of foundry work made, where two pieces of cast-iron were to be fitted one to the other, when the fitting surfaces were to be irregular and complicated. The first casting was made and slightly finished by filing or scraping, and then by special skill and practice the second piece was poured upon the first piece, and a very excellent and satisfactory fitting made in that way. I have also in the same way seen pieces cast together for journals, the journal being turned in the lathe, with care and accuracy as to its shape, so as to account for contraction, and then after that surface is thus prepared, the external portion poured upon it, and a complete and almost perfect fit made for a journal which would serve admirably for a large pressure and slow motion. Some fifteen years ago I cast a nut for a screw for very hard service on to a steel screw—common United States standard thread, 2½ inches diameter—and it has stood very hard service for fifteen years, with a wearing quality to it that I doubt very much could be obtained by machine-shop fitting.

The nut was 6 inches long, through which the steel screw worked with almost a perfect fit. Owing to the glazed surface of the cast-iron, the friction is small and the wearing qualities great.

I was recently visiting at the foundry of the Deane Steam Pump Co., of Holyoke, Mass., and there I saw a method for venting cores which they claimed was new with them. It consisted in placing twine or strings throughout the mass of the core, the twine or string being covered thickly with wax or tallow, so that when the core was placed in the oven and dried, and the wax or tallow melted, the strings could be easily pulled out of the core, and the whole mass was left free to carry off the gas.

Mr. John Richards.—I am not a little astonished at the slow progress which this art seems to have made, considering that it is now more than twenty-five years since the Ransomes of Ipswich, England, began molding by machinery. Mr. Ransome came to Philadelphia about twenty-five years ago, and called on William Sellers & Co., of Philadelphia, to introduce his methods, which they refused to adopt. He returned to England unsuccessful, but Messrs. Sellers & Co. soon after made what they called their pulley machines for molding pulleys, which have been in successful use ever since. I need not describe these. They are well known. I am not a molder myself, but I have observed the process a good deal, and I think that these processes which we are trying to introduce in the way of molding machines are not new; neither have they ever failed. It is want of attention, as Mr. Moore says.

What I want to speak about more particularly is this: Some years ago, in this city, in making barrel cores for pipes, the core barrels were wetted up with clay and laid in a frame and started to revolve. The sand was dropped about twenty feet on the top side of the bars as they revolved. The impingement of the sand was regulated by its weight and the distance of falling, in exact imitation of what a core-maker would do. The bars were revolved by machinery, perhaps at a rate of 30 or 40 revolutions per minute, and when brought to size the core was shaved down by a knife at the side. I have seen cores from three to six inches diameter, eight or ten feet long, made in 30 seconds from the time the sand started to fall on them. The impingement of the sand in that case was perfectly regular and uniform from end to end, and the result seemed to be wholly satisfactory. In the Ransome works at Ipswich there was a saving of metal by the machine processes equal to 10%; also a premium in price paid for the castings so made.

Mr. D. G. Moore.—The gentleman speaks of molding-sand. I have had considerable experience with molding-sand. I have found that sand used by the molder, where the mold was put up by hand, would need to be vented, the vent wire being used very freely, as is the custom. The same sand used in a molding machine would make a perfect mold without vents of any kind. It goes to show that the molding machine does its work more perfectly or more practically than the molder. It is not possible for a molder to ram a mold equally all over: he will ram it hard in some places and soft in others; it just depends upon how the man feels. We all know there are certain days when molders do their work less well than others; it is generally pretty close to pay day, too. The molding machine never gets affected in that way. The argument only goes to prove that the sand is all right. It is surprising what a molding machine will do—the amount of work it will do, and the perfect work. I have seen three and four hundred castings made every day from one pattern, and put on a scale, and it would be almost impossible to detect the slightest difference in weight. (I don't mean by that that it would be weighed on a druggist's scales or a scale made to weigh gold dust, but on an ordinary scale, which would weigh very close, a scale that would weigh to a quarter of a pound accurately). Such a scale does not show the least particle of variation in the weight of the castings made by machine.

I did not come here to advertise any machine, but it may give my argument a little more weight when I say that the company of which I am vice-president does manufacture the particular machine of which Mr. Tabor is the patentee, and we have had a great deal of chance and opportunity to make fair and reliable tests. I suppose we have from one to a dozen visitors every day looking at those machines in practical operation. We run two ourselves, and I think they are the best investment we ever made. You can put any kind of work upon them that comes in, and it is a very mistaken idea, as the author of the paper says, that you must have specially prepared patterns. You can mold any pattern. Of course if the castings are to be duplicated many times, it is best to make stripping plates, but any pattern that can be drawn by hand it will pay to put on the molding machine. And your castings are perfect; they don't require any cleaning as compared to castings made by hand, and I don't think there is any one, if he would only try the molding machine, who would ever be without it. It seems strange that they are so hard to introduce. A man will buy all improved tools for his machine shop; he will buy special lathes and everything that is needed to cut down the cost of work, but about the molding machines he is skeptical. He seems to think that nothing can be made in a foundry except it is made by a molder in the old-fashioned way.